to a switching signal provided to the micro-electro-mechanical switch die wherein the switching signal has a maximum voltage less than 10 Volts.

24. An optical cross connect comprising:

N optical input ports where N is an integer;

N optical output ports where; and

N times N micro-electro-mechanical system optical switch dice, each of the micro-electro-mechanical system optical switch dice having a drive capable of switching a mirror from a first position to a second position in response to a switching signal provided to the micro-electro-mechanical switch die wherein the optical cross connect switches 2N optical switch dice in less than about 50 mS with an average power consumption of less than about 2N/50 Watts.

REMARKS

Status of the Claims

Claims 1-37 are pending. The Applicants sincerely thank the Examiner for allowing claims 16 and 17, and for indicating the allowability of claims 2, 9-11, 14, 15, 19, 23, and 24 if rewritten in independent form including all of the limitations of the base claims and any intervening claims. Claims 1, 3-8, 12, 13, 18, 20-22 and 25-37 stand rejected.

Claims 2, 9, 14, 15, 19, 23, and 24 are amended in response to the Examiner's objection of these claims, and the undersigned believes these amendments do not add new matter and address the objections in a self-evident manner. Accordingly, the Applicants respectfully request removal of the objections of these claims, and their allowance. Claims 3 and 5 have been amended to correct obvious spelling errors. The undersigned believes these amendments do not add new matter.

The Applicants also thank the Examiner for accepting the formal drawings that were mailed May 22, 2001, and received by U.S. Patent Office on May 29, 2001, in response to the Notice to File Corrected Application Papers mailed 04/30/2001.

The undersigned has amended the first paragraph of the application in accordance with the Interview Summary of the telephonic interview between the Examiner and the undersigned on May 14, 2002, and sincerely thanks the Examiner for indicating that it is unnecessary for the applicant to provide a separate record of the substance of the interview.

The undersigned believes these amendments do not add new matter.

Rejections under 35 U.S.C. § 102

Claims 1, 3-8, 13, 18, 20-22, and 25-28 stand rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,389,189 by Edwards et al. (hereinafter "Edwards"). The Examiner cites Edwards for disclosing a micro-electro-mechanical system die mounted on an edge to a mounting substrate with a mirror moving from a first position in a plane essentially normal to a major surface of the mounting substrate, and an input port disposed to couple an optical signal to a first output port when the mirror is in the first position and to couple the optical signal to a second output port when the mirror is in the second position. The Applicants respectfully traverse the Examiner's position.

Claim 1, as amended, recites a mirror rotating from a first position to a second position in a plane essentially normal to a major surface of the mounting substrate to couple the an optical signal from an input port to one of a first or second output port. In other words, the optical switch recited in claim 1 rotates a mirror from one switch position to another during the optical switching operation. The switching element disclosed in Edwards uses a sliding MEMS mirror 22 (Col. 4, line 65) that is slid in and out of the cross-point (optical path) depending on the desired switch position (Col. 5, lines 49-54), and is not rotated during optical switching operations. Edwards discloses that the mirror is rotated during assembly (Col. 7, lines 21-32); however, such rotation does not anticipate or suggest claim 1. Alternatively, Edwards discloses forming a sliding mirror using a bulk micro-machining technique, in which case the mirror is not rotated. Col. 7, lines 44-51. Accordingly, the Applicants believe claim 1 and all claims that depend from claim 1 are allowable.

Furthermore, claim 1 recites a MEMs die mounted on an edge. The undersigned respectfully directs the Examiner's attention to Fig. 1A, ref. num. 21, which illustrates the edge of a MEMs die. As discussed in the written description associated with Figs. 5A-5D, mounting an individual die on a substrate provides several advantages, such as mounting only good (pre-tested) dice and allowing for individual optical alignment of switching die. Mounting the die on its edge allows the indicated operation of the optical switch. These advantages are not obtained if all the switching elements are fabricated at once on a substrate, as disclosed in Edwards (Col. 4, lines 53-64). Therefore, this element of claim 1

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is not disclosed or suggested by Edwards, and the Applicant believes claim 1 and all claims that depend from claim 1 are allowable, and respectfully request reconsideration of claims 1 and 3-5.

Claim 4 recites that the input port provides the optical signal to the mirror in the second position at an angle of less than about 22.5 degrees from a normal of the mirror. The Examiner asserts that Edwards discloses this, with reference to Fig. 1. The undersigned respectfully traverses the Examiner's position, and believes that Fig. 1 of Edwards shows the optical signal forming an angle of about 45 degrees from the normal of the mirror. This produces an included angle (the angle between the input and reflected beams) of 90 degrees, as shown in the switching grid of Edwards illustrated in Fig. 1. The recited angle of 22.5 degrees results in an included angle of about 45 degrees, which can reduce polarization conversion loss, as discussed on page 26, lines 9-13 of the Specification. Therefore, the Applicants believe claim 4 is further patentable.

Claim 6 recites, among other elements, that the first optical switching element is rotated in a plane essentially normal to the mounting surface out of the beam path. The Examiner asserts that Edwards discloses this element, and refers to Col 6, lines 14-21 and Col. 7, lines 20-30. The Applicants respectfully traverse the Examiner's position.

As discussed above in support of amended claim 1, Edwards does not rotate the switching elements into and out of the beam path, but rather slides the switching element in a trench. Edwards fabricates the mirror of the switching element in the major plane of the substrate, and then rotates the mirror so that it can slide along the slider track in a trench. Col. 7, lines 30-32. In other words, the mirror disclosed in this embodiment of Edwards is rotated from a plane parallel to the major surface of the substrate to a plane normal to the major plane of the substrate, but is not rotated in the plane normal to the mounting surface. Thus, the device disclosed in Edwards is completely different from the device of claim 6, and claim 6 and all claims that depend from claim 6 are patentable. Reconsideration of claims 6 and 13, removal of the rejections, and allowance of claims 6 and 13 is respectfully requested.

Claim 18 recites, among other elements, that the first mirror is rotated in a plane essentially normal to the mounting surface out of the beam path to latch in a retracted position. As discussed above in support of amended claim 1 and of claim 6, Edwards does not rotate a mirror in a plane essentially normal to the mounting surface out of the beam

path to latch in a retracted position; hence the Applicants believe claim 18 is allowable and respectfully request reconsideration of claim18, removal of this rejection, and the allowance of claim 18.

Claim 20 recites, among other elements, N times M micro-electro-mechanical system optical switch dice. The Examiner asserts that Edwards discloses N time M MEMS optical switch dice in Col. 4, lines 43-52. The Applicants respectfully traverse the Examiner's position. As illustrated in Figs. 5A-5D and discussed in the associated written description, the dice recited in claim 20 are individual components that are mounted on a substrate. They can be individually pre-tested, placed, and optically aligned. Optical alignment may be optimized according to the position of a die in a switching array. In contrast, Edwards appears to fashion all of the switching elements on a single substrate, Col. 4,lines 55-60, which is flip-chip bonded to another substrate. This technique does not disclose or suggest the switch dice recited in claim 20, and does not obtain its advantages. Accordingly, the Applicants believe claim 20 and all claims that depend from claim 20 are allowable, and respectfully request reconsideration of these claims and removal of the rejections.

Claim 25 recites, among other elements, aligning and affixing a first MEMS die to a mounting substrate, and aligning and affixing a second MEMS die to the mounting substrate. As discussed above in reference to claim 20, Edwards appears to fabricate the entire switching element array on a single substrate, which does not allow alignment of individual die. Accordingly, the Applicants believe that claim 25 is not anticipated or suggested by the cited art, and is allowable, as are all claims that depend from claim 25. Reconsideration of this claim and removal of these rejections is respectfully requested.

Claims 29-37 stand rejected under 35 U.S.C. §102(e) as being anticipated by U.S. Patent No. 6,256,430 by Jin et al. (hereinafter "Jin"). The Examiner cites Jin for disclosing a method of operating an optical cross connect by measuring the impedance of a circuit to determine a switch state and comparing the switch state output to an expected switch state. The Applicants respectfully traverse the Examiner's position.

Claim 29 recites, among other elements, measuring the impedance of a first circuit, and comparing the impedance to a reference value <u>to determine a switch state</u>. Jin appears to use <u>positional information</u> to activate additional, incremental, or reduced pulse current to one or more of the solenoids. There is no indication that the positional information is

equivalent to, or suggestive of, measuring the impedance of the circuit. Rather, it suggests that Jin measures the position of the light beam, and uses this positional information in a feedback system to adjust the position to the desired location by changing the drive to the circuit.

As discussed in the specification on page 27, lines 1-8, measuring the impedance can determine the switch state without disrupting the optical path. In an optical system, many switching cells might be present between the test light source and test light detector. The failure of any one of the cells would cause a failure in the light signal path; however, testing the impedance of each cell could pinpoint the failed node. This allows corrective measures to be directed at a single cell, rather than a global re-set of the entire switching path; again, all without disrupting the optical path. Accordingly, the Applicants believe claim 29 is not disclosed or suggested by the cited reference, and respectfully request reconsideration of this claim and removal of this rejection, and believe that claim 29 and all claims that depend from claim 29 are allowable.

Claims 33-36 are believed to be allowable for at least the reasons presented above in support of claim 29.

Claim 37 recites, among other elements, providing a plurality of electronic control signals to a plurality of micro-electro-mechanical system optical switch dice. Jin discloses an array of light–reflecting mirrors mounted on a common substrate. An array of programmable magnets are mounted on separate holders. The magnet arrays are preferably pre-assembled, brought close to the substrate, and aligned. Col. 5, lines 10-24, Fig. 3. Thus Jin does not disclose or suggest the recited plurality of micro-electro-mechanical system optical switch dice, and therefore cannot suggest the claimed step of providing a plurality of electronic control signals to the dice. Accordingly, claim 37 is believed to be allowable, and reconsideration of claim 37 and removal of its rejection are respectfully requested.

Rejections under 35 U.S.C. §103

Claim 12, which depends from claim 6 and is therefore patentable for at least the reasons given above in support of claim 6, stands rejected as being unpatentable over Edwards in further view of Jin. The Examiner asserts that Edwards discloses claim 12 except for a latching MEMs optical switch cell that maintains switch state without applied

electrical power, and that Jin discloses a latching optical switch cell that maintains switch state without applied electrical power. The Examiner further asserts that it would be obvious for one of ordinary skill in the art to provide the latching optical switch cell of Jin with the MEMs optical cross connect of Edwards. The Applicants respectfully traverse the Examiner's position.

To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, and not based on applicant's disclosure. While Edwards discloses that magnetic actuators might be used, there is no suggestion that the latching magnets disclosed in Jin could be adapted for use in the device of Edwards, or that such modification would have a reasonable expectation of success.

Edwards states that "[w]hen the addressable electrode is de-energized, transistor **250** provides no power to actuator **25** and mirror **22** is in the closed position. Hence, light is reflected by mirror **22** into output port **19** (not shown). When power is applied to the addressable electrode transistor **250** is energized and an electrostatic force is present on actuator **25**. Plate **220** is flexed upward by the electrostatic force and mirror **22** is lifted out of trench **15** into an open switch position." Col. 8, lines 38-46. This implies that the electrode must be energized to lift the mirror to the open position and teaches away from the claimed invention wherein the latching optical switch cell can maintain either switch state without applied electrical power. It is further unclear that the multi-layer, multi-electromagnet array of Jin (*see, e.g.* Fig. 3) could be adapted to the flip-chip wafer system or single-wafer fabrication techniques of Edwards with a reasonable expectation of success. More particularly, it is necessary that such expectation be found in the prior art; however, the Applicants find no such stated expectation. Therefore, the Applicants respectfully maintain that no *prima facie* case of obviousness exists, and request reconsideration of claim 12 and removal of this rejection.

Version of the Replacement Paragraphs With Markings to Show Changes Made

The following marked-up paragraphs show how the pending written specification and claims have been amended to result in the replacement paragraph and claims shown above.

IN THE WRITTEN SPECIFICATION

In the paragraph beginning on page 1, line 12:

This U.S. patent application is being concurrently filed with U.S. patent application serial no. [____________] 09/765,520 entitled, OPTICAL SWITCH WITH LOW-INERTIA MICROMIRROR by Feierabend et al. (Attorney Docket No. OC0100US); and U.S. patent application serial no. [____________] 09/764,919 entitled LOW INERTIA LATCHING MICROACTUATOR by Feierabend et al. (Attorney Docket No. 111500-IMT).

IN THE CLAIMS

Only the amended claims are shown below:

1. [AMENDED] An optical switch comprising:

a mounting substrate

a micro-electro-mechanical system ("MEMs") die mounted on an edge to the mounting substrate, the MEMs die including a mirror movably attached to a base portion of the MEMs die with a flexure hinge, the mirror **[moving]** rotating from a first position to a second position in a plane essentially normal to a major surface of the mounting substrate;

an input port disposed to couple an optical signal to

a first output port when the mirror is in the first position and to couple the optical signal to

a second output port when the mirror is in the second position.

2. [AMENDED] An optical switch comprising:

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a mounting substrate

a micro-electro-mechanical system ("MEMs") die mounted on an edge to the mounting substrate, the MEMs die including a mirror movably attached to a base portion of the MEMs die with a flexure hinge, the mirror moving from a first position to a second position in a plane essentially normal to a major surface of the mounting substrate;

an input port disposed to couple an optical signal to

a first output port when the mirror is in the first position and to couple the optical signal to

a second output port when the mirror is in the second position **[The optical switch of claim 1]** wherein the mirror is formed on a smoothed major crystal plane of a layer of single-crystal silicon and has a reflectivity greater than 96%.

3. The optical switch of claim 1 wherein the input port provides the optical signal to the mirror in the second position at an angle of between about 15-45 **[degress]** degrees from a normal of the mirror.

5. The optical switch of claim 1 wherein the mirror has a first mirrored surface and a second mirrored surface, the second mirrored surface being opposite the first mirrored surface, and further **[compising]** comprising

a second input port disposed to optically couple a second optical signal to the first output port when the mirror is in the second position.

9. [AMENDED] A micro-electro-mechanical system ("MEMs") optical cross connect comprising:

a mounting substrate having a mounting surface;

a first MEMs optical switch cell affixed to the mounting surface on an edge of the first MEMs optical switch cell and aligned to direct a first optical beam propagating along a beam path from a first optical input to a first optical output when a first metallic mirror of the first MEMs optical switch cell is in the beam path; and

a second MEMs optical switch cell affixed to the mounting surface and aligned to direct the first optical beam from the first optical input to a second optical output when a second metallic mirror of the second MEMs optical switch

cell is in the beam path and the first optical switching element is rotated in a plane essentially normal to the mounting surface out of the beam path **[The MEMs optical cross connect of claim 8]** wherein at least one of the first metallic mirror and the second metallic mirror has a minimum face dimension greater than about 400 microns.

14. [AMENDED] A micro-electro-mechanical system ("MEMs") optical cross connect comprising:

a mounting substrate having a mounting surface;

a first MEMs optical switch cell affixed to the mounting surface on an edge of the first MEMs optical switch cell and aligned to direct a first optical beam propagating along a beam path from a first optical input to a first optical output when a first optical switching element of the first MEMs optical switch cell is in the beam path; and

a second MEMs optical switch cell affixed to the mounting surface and aligned to direct the first optical beam from the first optical input to a second optical output when a second optical switching element of the second MEMs optical switch cell is in the beam path and the first optical switching element is rotated in a plane essentially normal to the mounting surface out of the beam path

wherein the first optical switching element is a two-sided mirror having a first mirrored side and a second mirrored side, the first optical beam reflecting off the first mirrored side of the two-sided mirror when the two-sided mirror is in the beam path and further comprising

a second optical input disposed to provide a second optical beam to the second mirrored side of the two-sided mirror when the two-sided mirror is in the beam path, the second optical beam being reflected off the second mirrored side to

a third optical output wherein the first optical beam optically couples to the third optical output when the first optical element and the second optical element are both switched out of the beam path

[The optical cross connect of claim 13] wherein the first mirrored side has a reflectivity greater than 96% and the second mirrored side has a reflectivity greater than

96%, each of the first mirrored side and the second mirrored side being formed on a smoothed major crystal plane of a layer of single-crystal silicon.

15. [AMENDED] A micro-electro-mechanical system ("MEMs") optical cross connect comprising:

a mounting substrate having a mounting surface;

a first MEMs optical switch cell affixed to the mounting surface on an edge of the first MEMs optical switch cell and aligned to direct a first optical beam propagating along a beam path from a first optical input to a first optical output when a first optical switching element of the first MEMs optical switch cell is in the beam path; and

a second MEMs optical switch cell affixed to the mounting surface and aligned to direct the first optical beam from the first optical input to a second optical output when a second optical switching element of the second MEMs optical switch cell is in the beam path and the first optical switching element is rotated in a plane essentially normal to the mounting surface out of the beam path **[The optical cross connect of claim 6]** wherein the first optical input is disposed between 12-57 mm from the first optical output.

19. [AMENDED] A micro-electro-mechanical system ("MEMs") optical cross connect comprising:

a mounting substrate having a mounting surface;

a first latching MEMs optical switch cell affixed to the mounting surface and aligned to direct a first optical beam from a first optical input to a first optical output when a first mirror of the first MEMs optical switch cell is latched in an extended position; and

a second MEMs optical switch cell affixed to the mounting surface and aligned to direct the first optical beam from the first optical input to a second optical output when a second mirror of the second MEMs optical switch cell is latched in a second extended position and the first mirror is rotated in a plane essentially normal to the mounting surface out of the beam path to latch in a retracted position **[The optical cross connect of claim 18]** wherein the first mirror in the extended position extends above an edge of the first latching MEMS optical switch cell at least 400 microns.

23. [AMENDED] An optical cross connect comprising:

N optical input ports where N is a first integer;

M optical output ports where M is a second integer; and

N times M micro-electro-mechanical system optical switch dice, each of the micro-electro-mechanical system optical switch dice having a magnetic drive capable of switching a mirror from a first position to a second position in response to a switching signal provided to the micro-electro-mechanical switch die **[The optical cross connect of claim 22]** wherein the switching signal has a maximum voltage less than 10 Volts.

24. [AMENDED] An optical cross connect comprising:

N optical input ports where N is an integer;

N optical output ports where; and

N times N micro-electro-mechanical system optical switch dice, each of the micro-electro-mechanical system optical switch dice having a drive capable of switching a mirror from a first position to a second position in response to a switching signal provided to the micro-electro-mechanical switch die **[The optical cross connect of claim 21]** wherein the optical cross connect switches 2N optical switch dice in less than about 50 mS with an average power consumption of less than about 2N/50 Watts.

CONCLUSION

In view of the foregoing, the Applicants believe that upon entry of this amendment all claims pending in this Application will be in condition for allowance. The Applicants respectfully request entry of this Amendment, reconsideration of the amended claims, withdrawal of the rejections, and the issuance of a formal Notice of Allowance at an early date.

If the Examiner believes this amendment does not put all pending claims in condition for allowance, the undersigned respectfully requests a telephone interview to

expedite prosecution of this application, and invites the Examiner to telephone the undersigned at (707) 591-0789.

Respectfully submitted,

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